

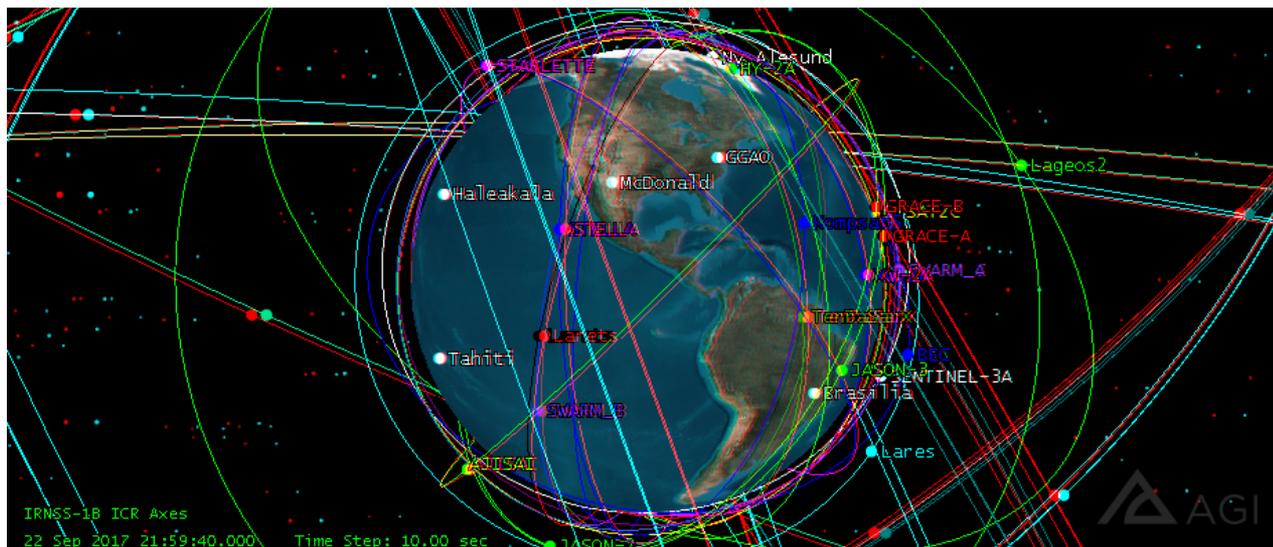


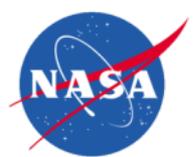
Scheduling the NASA SGSLR Network



Abstract: Over a decade ago, Honeywell Technology Solutions Inc (HTSI, now KBRwyle) developed an intelligent SLR scheduling software package during the development of the Matera Laser Ranging Observatory. This package offered a broad advanced capability to produce prioritized SLR schedules using multiple optimizations, including evolving satellite priority based on mission data requirements. HTSI further developed this software package for NASA and installed it at the NASA Data Operation Center to be used for all routine scheduling for participating NASA operational stations and the NGLSR. Although a number of the software's capabilities were used in scheduling the NASA stations, much of the broader capability, including coordinated Network scheduling, was left unused due to of the lack of system automation as well as the lack of satellite scheduling interferences. As the satellite roster continues to increase with the launch of multiple navigation constellations, experimental satellites, and Earth observers, it is important to work toward scheduling networks rather than individual stations, in order to fully meet the ILRS performance requirements. In addition, with the increased automation of SLR stations, the ability to make full use of this scheduling capability is finally being realized. NASA and KBRwyle plan to further develop this Network scheduling tool to intelligently schedule the next generation Space Geodesy Satellite Laser Ranging (SGSLR) Network. This poster will explore the current NASA scheduling capabilities as well as our vision for the future of the SGSLR Network scheduling.

- The future NASA scheduling package, will provide
 - Dynamic scheduling for each individual SGSLR system
 - Network scheduling coordination for the entire SGSLR Network
- Current NASA scheduler design and built by Bart Clarke (KBRwyle):
 - Uses multiple dynamic inputs and assigned inputs
 - Maximizes satellite mission requirements
 - Use ILRS priorities to develop initial schedule
 - Station specific information (day/night tracking)
 - Uses Multiple feature to enhance/optimize system schedule

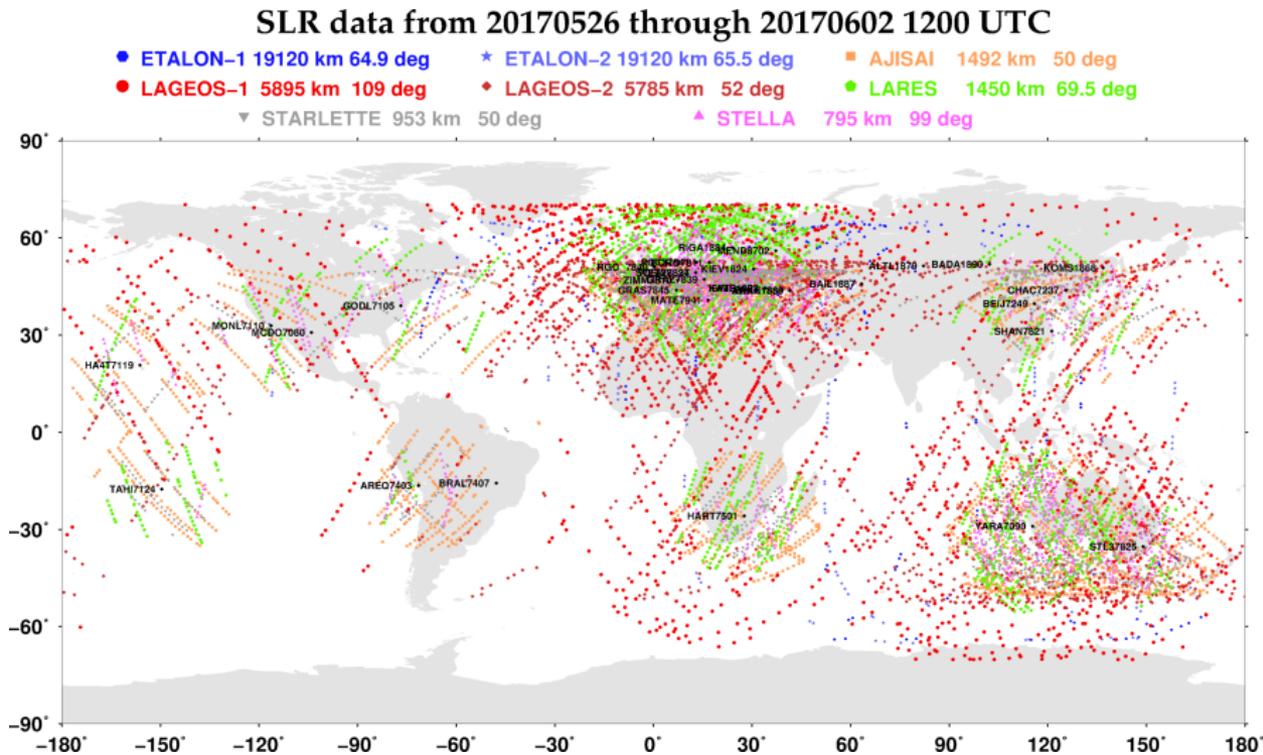




SGSLR Schedule features



- **Recently tracked Global SLR data Optimization:**
 - Satellite position and the amount of recently tracked data is considered during scheduling for changes to satellite
 - Scheduler can change satellite priorities for all SGSLR station schedules, for individual stations, or for stations located in clusters depending on geographic location.



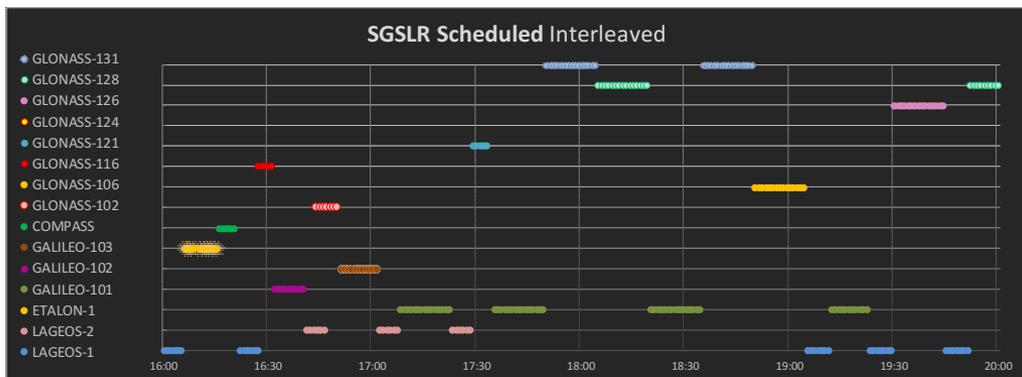
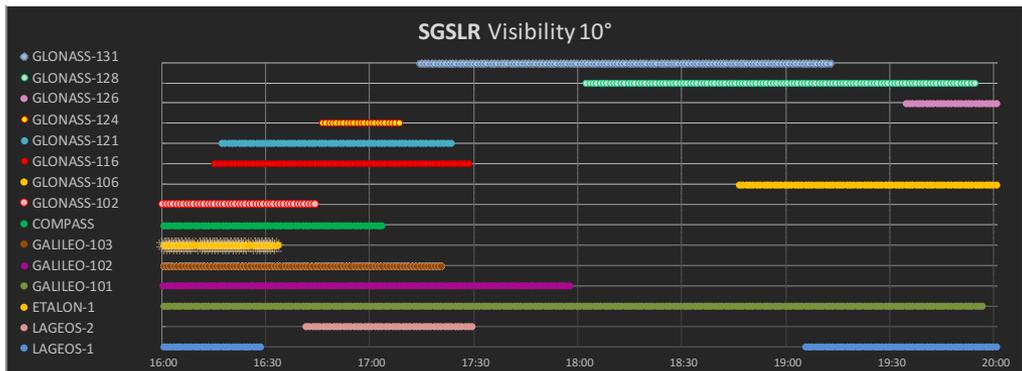


SGSLR Schedule features

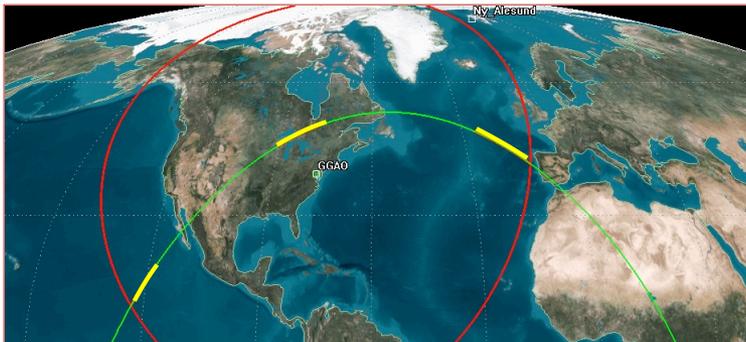


- **Interleaving Optimization**

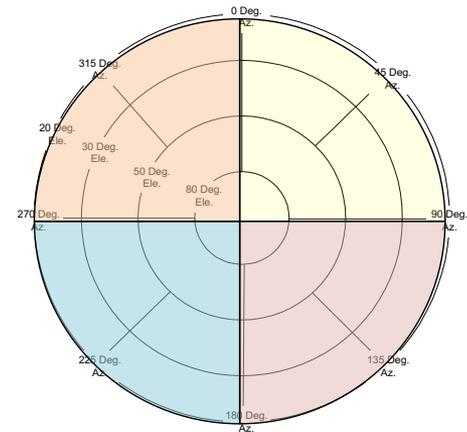
- Interleaving optimization for a satellite the schedule will alternate between that satellite and lower priority satellites at a given time interval.
- Avoids scheduling scenarios where one satellite of a group of similarly prioritized satellites is scheduled a disproportionate amount of time.



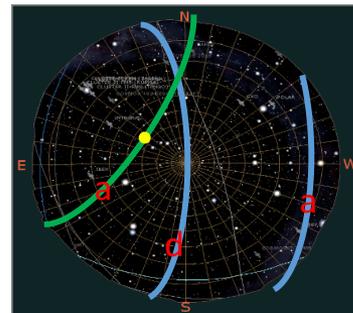
- **AOS, PCA, LOS Optimization:**
allows for AOS/PCA/LOS optimization by raising the priority of a satellite at the beginning, end, and the PCA of a pass.



- **Geodetic Sky Coverage Optimization:**
used to assist in scheduling complete sky coverage for a satellite. Using geodetic optimization the sky is divided into sections based on azimuth and elevation.



- **Ascending/Descending Optimization:**
assists in obtaining even distribution data in ascending and descending nodes while using recently tracked data.





SGSLR SGNOC



- **Space Geodesy Network Operations Center:**
 - Future SGSLR systems will be operated and monitored from a central facility at Goddard Space Flight Center called the Space Geodesy Network Operations Center (SGNOC).
 - SGSLR system and Network scheduling will be done at the SGNOC
- **Example of SGNOC Monitoring display:**

SLR NETWORK STATUS 2/17/2017 14:35 UTC

Greenbelt Ny-Ålesund McDonald Haleakala Hartebeesthoek Yarragadee Tahiti Station "n"

GREENBELT System Status

Mode: Tracking Target type: Satellite
Target: LAGEOS-2 SID: 5986

Local Date/Time: 2/17/2017 14:35 EST

Schedule

SIC	Start Date	Start Time	Duration	Priority	Satellite
9122	20130201	18:03	00:27	24	GLONASS-122
1025	20130201	18:30	00:09	9	Jason-2
7101	20130201	18:30	00:07	15	Galileo-101
7103	20130201	18:30	00:09	15	Unknown SIC
9129	20130201	18:30	00:09	18	Unknown SIC
9122	20130201	18:30	00:09	24	GLONASS-122
7103	20130201	18:39	00:10	15	Unknown SIC
9129	20130201	18:39	00:10	18	Unknown SIC
9122	20130201	18:39	00:10	24	GLONASS-122

Return Rate / Hits

Alert Messages (click alert to go to subsystem/com)

1. Camera 4 - Near enclosure min temp
2. UPS - Low Battery resolved
3. etc.

SLR MET SUBSYSTEM STATUS 2/17/2017 14:35 UTC

Greenbelt Ny-Ålesund McDonald Haleakala Hartebeesthoek Yarragadee Tahiti Station "n"

GREENBELT METEOROLOGICAL SUBSYSTEM STATUS

Local Date/Time: 2/17/2017 14:35 EST

ALL SKY CAMERA

Regional Clarity

Direction: Wind 281°, Dome 11°, Δ (W&D) 90°

Subsystem Specific Alert Messages

PRECIPITATION / H. VISIBILITY

TEMPERATURE / HUMIDITY

PRESSURE

ANEMOMETER



SGSLR Network Scheduling



- **NASA SGSLR Network Scheduling:**
 - The SGNOC will generate schedules for all systems in the NASA Network
 - The SGNOC will coordinate schedules based on:
 - ILRS priorities
 - geographic location
 - mission requirements
 - restricted tracking requirements
 - recent tracking and scheduling optimization inputs.

2/17/2017
14:35 UTC

Greenbelt
Ny-Ålesund
McDonald
Haleakala
Hartebeesthoek
Yarragadee
Tahiti
Station "n"

SCHEDULES

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Greenbelt						McDonald						Hartebeesthoek					
SIC	Start Date	Start Time	Duration	Priority	Satellite	SIC	Start Date	Start Time	Duration	Priority	Satellite	SIC	Start Date	Start Time	Duration	Priority	Satellite
9122	20130201	18:03	00:27	24	GLONASS-122	9122	20130201	18:03	00:27	24	GLONASS-122	9122	20130201	18:03	00:27	24	GLONASS-122
1025	20130201	18:30	00:09	9	Jason-2	1025	20130201	18:30	00:09	9	Jason-2	1025	20130201	18:30	00:09	9	Jason-2
7101	20130201	18:30	00:07	15	Galileo-101	7101	20130201	18:30	00:07	15	Galileo-101	7101	20130201	18:30	00:07	15	Galileo-101
7103	20130201	18:30	00:09	15	Unknown SIC	7103	20130201	18:30	00:09	15	Unknown SIC	7103	20130201	18:30	00:09	15	Unknown SIC
9129	20130201	18:30	00:09	18	Unknown SIC	9129	20130201	18:30	00:09	18	Unknown SIC	9129	20130201	18:30	00:09	18	Unknown SIC
9122	20130201	18:30	00:09	24	GLONASS-122	9122	20130201	18:30	00:09	24	GLONASS-122	9122	20130201	18:30	00:09	24	GLONASS-122
7103	20130201	18:39	00:10	15	Unknown SIC	7103	20130201	18:39	00:10	15	Unknown SIC	7103	20130201	18:39	00:10	15	Unknown SIC
9129	20130201	18:39	00:10	18	Unknown SIC	9129	20130201	18:39	00:10	18	Unknown SIC	9129	20130201	18:39	00:10	18	Unknown SIC
9122	20130201	18:39	00:10	24	GLONASS-122	9122	20130201	18:39	00:10	24	GLONASS-122	9122	20130201	18:39	00:10	24	GLONASS-122

Ny-Ålesund						Haleakala						Yarragadee					
SIC	Start Date	Start Time	Duration	Priority	Satellite	SIC	Start Date	Start Time	Duration	Priority	Satellite	SIC	Start Date	Start Time	Duration	Priority	Satellite
9122	20130201	18:03	00:27	24	GLONASS-122	9122	20130201	18:03	00:27	24	GLONASS-122	9122	20130201	18:03	00:27	24	GLONASS-122
1025	20130201	18:30	00:09	9	Jason-2	1025	20130201	18:30	00:09	9	Jason-2	1025	20130201	18:30	00:09	9	Jason-2
7101	20130201	18:30	00:07	15	Galileo-101	7101	20130201	18:30	00:07	15	Galileo-101	7101	20130201	18:30	00:07	15	Galileo-101
7103	20130201	18:30	00:09	15	Unknown SIC	7103	20130201	18:30	00:09	15	Unknown SIC	7103	20130201	18:30	00:09	15	Unknown SIC
9129	20130201	18:30	00:09	18	Unknown SIC	9129	20130201	18:30	00:09	18	Unknown SIC	9129	20130201	18:30	00:09	18	Unknown SIC
9122	20130201	18:30	00:09	24	GLONASS-122	9122	20130201	18:30	00:09	24	GLONASS-122	9122	20130201	18:30	00:09	24	GLONASS-122
7103	20130201	18:39	00:10	15	Unknown SIC	7103	20130201	18:39	00:10	15	Unknown SIC	7103	20130201	18:39	00:10	15	Unknown SIC
9129	20130201	18:39	00:10	18	Unknown SIC	9129	20130201	18:39	00:10	18	Unknown SIC	9129	20130201	18:39	00:10	18	Unknown SIC
9122	20130201	18:39	00:10	24	GLONASS-122	9122	20130201	18:39	00:10	24	GLONASS-122	9122	20130201	18:39	00:10	24	GLONASS-122



SGSLR Network Real-time Scheduling



- The SGNOC will also command stations to increase or decrease satellite priorities based on real-time information coming from the Global ILRS dataset. Commands will be pushed to the Network or to individual stations to automatically change satellite priorities.
- The SGNOC will also provide alerts about tracking performance on a public facing page to encourage all ILRS systems to increase/decrease tracking priorities based on the most recent ILRS tracking.

SLR NETWORK SCHEDULE

2/17/2017
14:35 UTC

Greenbelt
Ny-Ålesund
McDonald
Haleakala
Hartebeesthoek
Yarragadee
Tahiti
Station "n"

CURRENTLY BEING TRACKED
← Page 1 of x →

	Greenbelt	Ny-Ålesund	McDonald	Haleakala	Hartebeesthoek	Yarragadee	Tahiti	Station "n"
Stallite	Jason-2	Lageos	Gallileo-101	Compass-M3	GLONASS-122	Lageos-2	Etalon	"Sat. Name"
SIC	1025	1155	7101	2004	9122	5986	525	[nnn]
Start Date (UTC)	1/2/2017	1/2/2017	1/2/2017	1/2/2017	1/2/2017	1/2/2017	1/2/2017	[mm/dd/yyyy]
Start Time (UTC)	18:30	18:30	18:30	18:30	18:30	18:30	18:30	[hh:mm]
Duration (min.)	15	18	10	27	22	15	8	[mm:ss]
Priority	14	5	11	9	24	10	18	[xx]

Tracking Optimization Messages

1. NASA Network – Increased priority for all descending passes for LARES (5987)
2. NASA Network – Interleaving optimization enabled for all same priority satellites
3. NASA Network – Increased priority for GALILEO-102 for LARGE campaign
4. NASA Network – Lack of data. Command -Raise priority for JASON-3 (4379)

Schedule Command Messages

1. NASA Network – Lack of global data. Command: Raise priority for JASON-3 (4379)
2. Hartebeesthoek Station – Lack of global and station data. Command: Raise priority for RNSS-1B (3302)
3. Yarragadee – Lack of global data. Command: Raise priority for RNSS-1B (3302)

The NASA/KBRwyle scheduler will provide optimized scheduling of an ever increasing number of ILRS satellites, which will improve productivity of the integrated network of SGSLR systems